PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2004-091902
(43)Date of publication of application : 25.03.2004

(51)Int.Cl. C23C 24/04
H01F 41/02

(21)Application number : 2002-258148
(22)Date of filing : 03.09.2002

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(54) METHOD OF FORMING FILM FOR RARE EARTH MAGNET

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a method of forming a corrosion resistant film for a rare earth magnet which has sufficient adhesion to be required at a low cost by a simple process.
SOLUTION: The formation of a film on a rare earth magnet is performed by colliding particles with a fine diameter against the surface of a rare earth magnet at high speed, fusing the particles themselves by energy between the rare earth magnet and the particles on the collision, and allowing the particles to spread over the surface of the rare earth magnet. The diameter of the particles lies in the range of 0.02 to 0.6 mm, and the particles are sprayed at a speed of 50 to 2,000 m/s using the air, or a high pressure inert gas or a mixture of the air and high pressure inert gas.

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CLAIMS

[Claim(s)]
[Claim 1]
A film formation method of a rare earth permanent magnet are a film formation method of a rare earth permanent magnet, particles of a minute diameter are made to collide on the surface of a rare earth permanent magnet at high speed, and the particle itself dissolves by energy at the time of a collision of said rare earth permanent magnet and particles, adhering to the surface of said rare earth permanent magnet, and forming a coat.
[Claim 2]
A film formation method of the rare earth permanent magnet according to claim 1 whose diameter of said particle is a range from 0.02 mm to 0.6 mm.
[Claim 3]
A film formation method of the rare earth permanent magnet according to claim 1 or 2 which sprays said particle using a mixture of air, high pressure inert gas, or air and high pressure inert gas.
[Claim 4]
A film formation method of the rare earth permanent magnet according to claim 3 whose speed in case said particle is sprayed is the range of 50 - 2000 m/s.
[Claim 5]
Make the 1st particle that has a predetermined presentation collide on the surface of a rare earth permanent magnet, and defecation and a ground film on the surface of a rare earth permanent magnet are formed in the rare earth permanent magnet surface, A film formation method of the rare earth permanent magnet according to any one of claims 1 to 4 which forms a multilayer film which made the 2nd particle that has a different presentation from the 1st particle of an account of back to front collide on the surface of a rare earth permanent magnet, and was laminated by two or more presentations.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]
This invention relates to the film formation method of a rare earth permanent magnet, and relates to what obtains a cheap and corrosion-resistant good rare earth permanent magnet compared with the former.
[0002]
[Description of the Prior Art]
About the film formation method, the film formation method by plating and the following resin of nickel etc. has been used conventionally. 1Electrodeposition coating method : by immersing parts in the fluid in which resin powder with an electric charge was suspended, and impressing voltage to parts by an external power, It is drawn on parts by resin powder with an electric charge, parts are covered by resin powder, the parts covered by resin powder are heated after that, and they are melting or/and a thing which constructs a bridge and forms a coat on the surface of parts about resin powder. 2Electrostatic coating method: By putting the parts to which voltage was impressed on the space which dispersed resin powder with an electric charge, draw resin powder on parts and form a resin powder coat in parts.
Then, the parts in which the resin powder coat was formed are heated, and they are melting or/and a thing which constructs a bridge and forms a coat on the surface of parts about resin powder.
3Spray coating method: Dilute resin with a solvent, evaporate a solvent after forming a coat by spraying this on parts by a spray, and they are melting or/and a thing which constructs a bridge and forms a coat in parts about resin. 4The dip-coating method: In the case of resin liquid with low viscosity, or resin with high viscosity, parts are immersed in the tub of the resin liquid which diluted with the solvent and lowered viscosity, make resin adhere on the surface of parts, and they are melting or/and a thing which constructs a bridge and forms a coat about after that and resin.

[0003]
However, the conventional film formation method which was mentioned above has a technical problem which is indicated below. Since it needs to be worked for attaching parts to an electrode in an electrodeposition coating method first and a film is not formed in the portion which attached the electrode, the work called the touch-up for dishing up resin to the portion is needed after coat formation. These work needs introduction of the robot etc. which carry out a help or a complicated motion, therefore will cause increase of the expense for coat formation. There is a problem of having to process used electrodeposition fluid as industrial waste. Since there is a problem which attaches [in / as well as said electrodeposition coating method / an electrostatic coating method] parts and a granular material disperses, there is danger, such as dust explosion, and the large-scale device for dust preventing scattering or the prevention from explosion is needed. Since the thickness of a coat is greatly dependent on operation of a spray gun in a spray coating method, thickness becomes uneven easily. After carrying out a spray to one field of parts, in order to carry out a spray to other fields, operation of turning parts is required. Antipollution measure processing is needed at the process which must dilute resin with a lot of solvents in order to spray-ize, and evaporates this solvent after spreading. moreover -- taking out parts from an immersion organ bath in the dip coating method -- the liquid in the case -- they are whom and liquid -- it is generated by the ball unescapable, and liquid does not adhere conversely, or it can be tended to perform an extremely thin place, and is unreliable compared with other methods as a film formation method.
[0004]
The method of applying to the Shimoji surface is indicated using mixing methods, such as a barrel, in the material into which the problem which these conventional film formation methods have is coped with and for which the binding material of a coat morphogenetic substance and a ground was mixed as law on the other hand as indicated by JP,6-154698,A, for example. However, in this method, in order for this mixture not to adhere to the Shimoji surface in uniform thickness and to combine a coat and a ground, if a ground is heated, only a binding material will dissolve or evaporate, but it fully dissolves, and a coat morphogenetic substance does not serve as a uniform coat, but serves as a coat only with the structure in which particles carried out lamination condensation. As a result, since a grain boundary exists in a coat, the coat formed by this method cannot fully intercept the moisture from the outside, etc., and cannot secure magnetic corrosion resistance. a magnet is immersed in the solution which mixed piece of phosphorus-like aluminum-metals foil to the coupling agent instead of the metal particles for coat formation as art for reducing the yield of such a grain boundary, and the method of forming the ingredient used as a coat in the magnet surface is indicated by JP,10-226890,A. However, in order to pass through the process which heightens the adhesion power of a film component and is further called removal of a coupling agent by putting the magnet to which the film component adhered by this method into a barrel tank after a drying process, and giving a shock to the magnet

surface with a stainless steel bead, A process becomes it is long and complicated and it is easy to generate dispersion in thickness, and especially, the thickness difference between a magnet corner and a flat-surface part is large, and there is a problem in which it is difficult to improve corrosion resistance uniformly at each magnetic place.

[0005]

[Problem(s) to be Solved by the Invention]

Therefore, in view of said fault inherent in the Prior art mentioned above, this invention was proposed so that it may solve this, and it is ****. The purpose is to provide the method of forming the corrosion resistance film for rare earth permanent magnets which has adhesion sufficient required by low cost by a process.

[0006]

[Means for Solving the Problem]

If a diameter of shot grains is made small in sandblasting or shot peening and it goes, jet velocity will increase, and this invention. Generation of heat arises in an injection surface of a workpiece slack permanent magnet, and it uses that injection skin temperature rises with an increase in jet velocity, In this case, using metal or an oxide particle with a diameters [20-200micro] which has hardness lower than magnet hardness on the surface of a permanent magnet as a coat formation material, that shot is injected with jet velocity of not less than 50 m/sec, and temperature near the surface of a rare earth permanent magnet is raised more than a transformation point. Although a material-list side receives damage mechanically by the repetition collision of a particle etc. and a phenomenon from which the part is desorbed is called erosion, If a shot which consists of spherical materials, such as minute simple substance metal or an alloy, is made to collide with an even portion of a relative very big permanent magnet with a spray processing machine of an air flow type using exhaust air or inactive gas, particles which collided will rebound on the magnet surface, but as for after a collision, speed becomes slow. A difference of kinetic energy of particles before and behind a collision serves as thermal energy, and thereby, particles are heated by elevated temperature and fuse it. And it checked that this fused particle formed film-like sedimentary layers on the surface of a permanent magnet. This is because stage film formation, i.e., shot coating, is produced after that by spray conditions, although a particle collision causes erosion in part in early stages. A uniform coat can be made to form in each field of a rare earth permanent magnet which is a collision object on the surface of [whole] a rare earth permanent magnet by injecting particles uniformly.

[0007]

That is, are a film formation method of a rare earth permanent magnet, particles of a minute diameter are made to collide on the surface of a rare earth permanent magnet at high speed, the particle itself dissolves by energy at the time of a collision of said rare earth permanent magnet and particles, and this invention adheres to the surface of said rare earth permanent magnet, and forms a coat. The diameter of this particle can form a coat

good for not doing damage to a chip, a crack, etc. to the rare earth permanent magnet itself as it is a range from 0.02 mm to 0.6 mm. As for this particle, it is desirable on industry to spray using a mixture of air, high pressure inert gas, or air and high pressure inert gas. When spraying particles at this time, speed is the range of 50-2000 m/s. Make the 1st particle that has a predetermined presentation collide on the surface of a rare earth permanent magnet, and defecation and a ground film on the surface of a rare earth permanent magnet are formed in the rare earth permanent magnet surface, The 2nd particle that has a different presentation from the 1st particle of an account of back to front can be made to be able to collide on the surface of a rare earth permanent magnet, and a multilayer film in which two or more kinds of presentations were laminated can be formed. If it is multilayer structure, even if thickness of this ground film is 10 micrometers or less, it can secure sufficient corrosion resistance.

[0008]

As for an effect, although a rare earth permanent magnet of this invention mainly points out a R-T(- M)-B (- C) system, a Sm-Co system, a R-T(- M)-N (- B) system, etc., even if other, it is natural that the same thing as this invention is obtained. One sort in a rare earth element in which R contains Y or two sorts or more, and T point out a transition metal here, and M points out one or more sorts of Ti, V, Cr, W, Mn, Ga, aluminum, Sn, Ta, Nb, and Si.

[0009]

[Embodiment of the Invention]

(Example 1)

Details when this invention carries out are given below. The air of original pressure 0.2 - 1.0MPa was made to blow off from the tip of a nozzle at high speed using the shot-blasting machine of a fixed cancer method first. Then, each simple substance metal particles of with a particle diameter [10-600micro] aluminum$_2O_3$, Zr, nickel, Cu, Sn, Zn, and Cr were individually put on this airstream, and the permanent magnet which is a processed material in a second in 100-200 m /was sprayed. Of course, the kinetic energy of particles increases and formation of a coat becomes easy, so that the speed of the particles sprayed is a high speed. However, if the speed of particles is too quick, the temperature on the surface of a magnet may become an elevated temperature too much at the time of the collision of particles, and the organization on the surface of a magnet may be deteriorated. Therefore, as for the speed of the optimal particles, it is desirable that it is in the range of 50 m/second - 2000 m/second. In the range of this particle velocity, since the rise in heat on the surface of a magnet is suppressed in the range of 500-900 **, the magnet surface becomes an elevated temperature in the depth of the range of 1-10 micrometers, but in order that a rise in heat may not progress in a depths part from it, there are nothings so that magnetic magnetic properties may be reduced. The permanent magnet used here used the NdFeB system as the base, and in order to secure it magnetic properties, the sample by having added a little alloying elements (Co, Dy, Tb, aluminum, Nb, Cu, Cr, Eu) if needed was used. As magnetic shape, a 15x45x3-mm block magnet, the light-gage form ring magnet of 2 mm

of outer diameter 30x inside diameter 10x thickness, a 30x50x10-mm large-scale block magnet, 35x40x8 mm, inner R150mm, and outside used the R158mm arc segment magnet.

[0010]

Making it, as for a spray angle, injection flow be equivalent to the field of a sample vertically, the distance from a nozzle tip to a specimen surface was 100-200 mm. The diameter of the nozzle used for the shot is obtained 2 mm, and there is, and construction material used super-steel materials. The time which the shot took was 20 seconds per each field. Under this condition, the thickness of the coat formed on the magnet is shown in the next table 1.

[0011]

[Table 1]

磁石表面の皮膜膜厚（μm）

粒子材質	Al2O3	Zr	Ni	Cu	Sn	Zn	Cr
膜厚	1	3	8	13	22	27	10

[0012]

As the result of Table 1 showed, by Cu, Sn, Zn, and Cr, the film of sufficient thickness was formed in the magnet surface practical, but by other elements, thickness was formed thinly. There was no influence by the difference in the shape of three kinds of magnets which carried out this time distribution of the thickness of the coat formed in the magnet surface. According to the tensile test, the adhesion strength with the ground magnet of the formed coat was in the range of 100 - 250 kg/cm^2, and was sufficient range practical as adhesion strength of a coat.

[0013]

(Example 2)

After applying shot blasting for the surface of each magnet beforehand in aluminum$_2O_3$ and making a surface state uniform, metal other than aluminum$_2O_3$ was injected and formation of the coat was checked. This is because it checked that a coat is formed only in slight thickness, but the magnet surface was ground by the blast effect and a uniform surface state was rather acquired by it compared with aluminum$_2O_3$'s spraying before, when aluminum$_2O_3$ particles are sprayed on a magnet. Since such a phenomenon is seen with Zr, Cr, and nickel besides aluminum$_2O_3$, it can acquire the effect of surface cleaning by spraying such construction material on the permanent magnet surface beforehand. Since a very thin film is formed in the magnet surface with such construction material, it is also possible to form the multilayer film by different-species construction material. In the case of

this example, each magnet is 20 seconds and the injection time of aluminum$_2O_3$ is 20 seconds also the injection time of other metal, respectively. As a result, the thickness according to construction material of the obtained coat is shown in Table 2.

[0014]

[Table 2]

磁石表面の皮膜膜厚（μm）

粒子材質	Zr	Ni	Cu	Zn	Cr
膜厚	5	11	14	24	9

[0015]

The big difference was not looked at by the thickness of the metal membrane attached after that even if it irradiated the magnet surface with aluminum$_2O_3$ particles beforehand, as the result of Table 2 showed. However, by the prior exposure of aluminum$_2O_3$, the affix on the surface of a magnet could be taken, and since a concavo-convex change also became small, dispersion in the thickness at the time of attaching a metal membrane fell with 8 micrometers -> 3 micrometers as compared with the case where it does not irradiate with aluminum$_2O_3$. The thickness distribution of the formed coat did not have the difference by magnetic shape like the case of Example 1. It checked that the adhesion strength of a coat was in the range of 100 - 200 kg/cm^2, and had improved compared with the case of Example 1.

[0016]

(Example 3)

The air of original pressure 0.2 - 1.0MPa was made to blow off from the tip of a nozzle at high speed using the shot-blasting machine of a fixed cancer method. The Ni alloy with a particle diameter of 10-600 micrometers was used as the first particle. These metal particles were sprayed on the permanent magnet which is a processed material in 100 - 200 m/s with said shot brass machine, and the Ni film of 8 micrometers of film pressure was obtained. Then, the Cu alloy with a particle diameter of 10-600 micrometers was used as the second particle. The film pressure of 12 micrometers of film pressure was formed by spraying on the surface of a rare earth permanent magnet like the first particle. The multilayer film which consists of nickel-Cu on the surface of a rare earth permanent magnet by this was formed.

[0017]

[Effect of the Invention]

It is only using equipment of a simple structure with a low price like a shot-blasting machine as the contents of the above-mentioned explanation show this invention, A coat can be

made to form in the magnet surface, and since a film formation process can be made to complete for a short time, a protective film can be made to form in the magnet surface by low cost very as compared with the conventional film formation method.

[Translation done.]

(19)日本国特許庁(JP)　(12)公開特許公報(A)　(11)特許出願公開番号
特開2004-91902
(P2004-91902A)
(43)公開日　平成16年3月25日(2004.3.25)

(51)Int.Cl.[7]	F I		テーマコード（参考）
C23C 24/04	C23C 24/04		4K044
H01F 41/02	H01F 41/02	G	5E062

審査請求 未請求　請求項の数 5　OL　（全 5 頁）

(21)出願番号　特願2002-258148(P2002-258148)
(22)出願日　平成14年9月3日(2002.9.3)

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Fターム(参考)　4K044 AA01 AB10 BA02 BA06 BA10 BA13 CA23 CA53
5E062 CD04 CG03 CG07

(54)【発明の名称】希土類磁石の皮膜形成方法

(57)【要約】
【課題】簡単な工程により低コストで必要十分な密着性を有する、希土類磁石用の耐食性皮膜を形成する方法を提供することを目的とする。
【解決手段】希土類磁石の皮膜形成方法であって、微小直径の粒子を高速で希土類磁石の表面に衝突させ、前記希土類磁石と粒子の衝突時のエネルギーにより粒子自身が融解して前記希土類磁石の表面に広がって皮膜を形成することを特徴とする希土類磁石の皮膜形成方法。前記粒子の直径は０．０２ｍｍから０．６ｍｍまでの範囲であり、５０～２０００ｍ／ｓの測度で粒子を空気または高圧不活性ガスまたは空気と高圧不活性ガスの混合物を用いて吹き付ける。

FP05-0116
JP

【特許請求の範囲】
【請求項１】
希土類磁石の皮膜形成方法であって、微小直径の粒子を高速で希土類磁石の表面に衝突させ、前記希土類磁石と粒子の衝突時のエネルギーにより粒子自身が融解して前記希土類磁石の表面に付着して皮膜を形成することを特徴とする希土類磁石の皮膜形成方法。
【請求項２】
前記粒子の直径は０．０２ｍｍから０．６ｍｍまでの範囲である請求項１に記載の希土類磁石の皮膜形成方法。
【請求項３】
前記粒子を空気または高圧不活性ガスまたは空気と高圧不活性ガスの混合物を用いて吹き付ける請求項１または２に記載の希土類磁石の皮膜形成方法。
【請求項４】
前記粒子が吹き付けられるときの速度は、５０～２０００ｍ／ｓの範囲である請求項３に記載の希土類磁石の皮膜形成方法。
【請求項５】
所定の組成を有する第１の粒子を希土類磁石の表面に衝突させて希土類磁石表面の清浄化および下地膜を希土類磁石表面に形成し、その後前記第１の粒子とは異なる組成を有する第２の粒子を希土類磁石の表面に衝突させ複数の組成で積層された多層膜を形成する請求項１～４のいずれかに記載の希土類磁石の皮膜形成方法。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】
本発明は希土類磁石の皮膜形成方法に係わるもので、従来に比べ安価でかつ耐蝕性の良好な希土類磁石を得るものに係わる。
【０００２】
【従来の技術】
皮膜形成方法については、従来Ｎｉ等のメッキや下記のような樹脂による皮膜形成方法が用いられてきた。▲１▼電着塗装方法：電荷を持つ樹脂粉体が懸濁された液体に部品を浸漬し、外部電源により部品に電圧を印加することにより、電荷を持った樹脂粉体が部品にひきつけられ、部品を樹脂粉体で覆い、その後、樹脂粉体で覆われた部品を加熱し、樹脂粉体を溶融または／および架橋して部品の表面に皮膜を形成するもの。▲２▼静電塗装方法：電荷を持つ樹脂粉体を飛散させた空間に、電圧が印加された部品を置くことにより、樹脂粉体を部品に引き付けて部品に樹脂粉体皮膜を形成し、その後、樹脂粉体皮膜が形成された部品を加熱し、樹脂粉体を溶融または／および架橋して部品の表面に皮膜を形成するもの。▲３▼スプレー塗装方法：樹脂を溶媒で希釈し、これをスプレーで部品に吹き付けることにより皮膜を形成した後、溶媒を蒸発させ、樹脂を溶融または／および架橋して部品に皮膜を形成するもの。▲４▼浸漬塗装方法：粘度の低い樹脂液あるいは粘度の高い樹脂の場合は溶媒で希釈して粘度を下げた樹脂液の槽内に部品を浸漬して、部品の表面に樹脂を付着させ、その後、樹脂を溶融または／および架橋して皮膜を形成するもの。
【０００３】
しかしながら、上述したような従来の皮膜形成方法は、以下に記載するような課題を有する。まず電着塗装方法においては部品を電極につけるための作業が必要であり、また電極を取り付けた部分には膜が形成されないので、皮膜形成後、その部分に樹脂を盛り付けるためのタッチアップと呼ばれる作業が必要となる。これらの作業は、人手または複雑な動きをするロボット等の導入が必要であり、従って、皮膜形成のための費用の増大を来すことになる。さらに、使用済みの電着液は産業廃棄物として処理しなくてはならない等の問題がある。静電塗装方法においても前記電着塗装方法と同じく部品を取り付ける問題があり、また粉体が飛散するため粉塵爆発等の危険性があり粉塵飛散防止や爆発防止のために大掛かりな装置が必要となる。また、スプレー塗装方法では皮膜の膜厚がスプレーガンの操作に大きく依存するので、膜厚が不均一になりやすい。部品のひとつの面にスプレーし

た後、他の面にスプレーするために部品をひっくり返す操作が必要である。スプレー化するために樹脂を多量の溶媒で希釈しなければならず、また塗布後、この溶媒を蒸発させる工程で公害対策処理が必要となる。また、浸漬塗装方法では、浸漬浴槽から部品を取り出し際の液だれ、液だまりが不可避的に発生し、また逆に液が付着しないか極端に薄いところができやすく、皮膜形成方法としては他の方法に比べ信頼性が低い。

【０００４】

これらの従来の塗膜形成方法のもつ問題点を対策する一方法として、例えば特開平６－１５４６９８号公報に開示されている様に、皮膜形成物質と下地との結合剤を混合した材料を、バレルなどの混合方法を用いて、下地表面に塗布する方法が開示されている。しかし、この方法では、下地表面にこの混合物が均一な膜厚で付着せず、また皮膜と下地を結合させるために下地を加熱すると、結合剤のみが融解または蒸発するが、皮膜形成物質は十分に融解して一様な皮膜とならず、粒子の積層凝集しただけの構造をもつ皮膜となる。この結果、この方法で形成された皮膜は、粒界が皮膜内に存在するために、外部からの水分などを十分に遮断することができず、磁石の耐食性を確保することができない。この様な粒界の発生量を低減させるための技術として、皮膜形成のための金属粒子の代わりに燐片状のアルミニウム金属箔をカプリング剤に混合した溶液に磁石を浸漬し、皮膜となる成分を磁石表面に形成する方法が特開平１０－２２６８９０号公報に開示されている。しかし、この方法では皮膜成分が付着した磁石を、乾燥工程の後、バレルタンクに入れ、ステンレス球で磁石表面に衝撃をあたえることにより、皮膜成分の密着力を高め、さらにカプリング剤の除去と言う工程を経るため、工程が長く複雑となり、膜厚にばらつきが発生しやすく、特に磁石角部と平面部の間の膜厚差が大きく、磁石の各場所で均一に耐食性を高めることが難しい問題がある。

【０００５】

【発明が解決しようとする課題】

よって本発明は、前述した従来の技術に内在している前記欠点に鑑み、これを解決するべく提案されたものであって、簡単な工程により低コストで必要十分な密着性を有する希土類磁石用の耐食性皮膜を形成する方法を提供することを目的とする。

【０００６】

【課題を解決するための手段】

本発明は、サンドブラストないしはショットピーニング等においてショット粒径を小さくして行くと、噴射速度が増大すると共に、被加工物たる永久磁石の噴射面に発熱が生じ、噴射表面温度が噴射速度の増加に伴って上昇することを利用したものであり、この際に永久磁石の表面に磁石硬度より低い硬度を有する直径２０～２００μの金属または酸化物粒子を皮膜形成材料として用い、そのショットを噴射速度５０ｍ／ｓｅｃ以上で噴射し、希土類磁石の表面付近の温度を変態点以上に上昇させることを特徴とする。固体粒子などの繰り返し衝突により材料表面が機械的に損傷を受け、その一部が脱離していく現象はエロージョンと呼ばれているが、微小な単体金属、または合金などの球状物体からなるショットをエアや不活性ガスを用いた気流式の吹き付け加工機により相対的に非常に大きな永久磁石の平らな部分に衝突させると、衝突した粒子は磁石表面で跳ね返るが、衝突後は速度が遅くなる。衝突前後の粒子の運動エネルギーの差は熱エネルギーとなり、これにより粒子が高温に加熱され溶融する。そしてこの溶融した粒子が永久磁石の表面に膜状の堆積層を形成することを確認した。これは、固体粒子衝突がエロージョンを初期には一部引き起こすものの、吹き付け条件により、その後に成膜工程、すなわちショットコーテイングを生じることによる。被衝突物である希土類永久磁石の各面に均等に粒子を噴射することで希土類永久磁石の表面全体に一様な皮膜を形成させることができる。

【０００７】

つまり本発明は、希土類磁石の皮膜形成方法であって、微小直径の粒子を高速で希土類磁石の表面に衝突させ、前記希土類磁石と粒子の衝突時のエネルギーにより粒子自身が融解して前記希土類磁石の表面に付着して皮膜を形成することを特徴とするものである。この粒子の直径は０．０２ｍｍから０．６ｍｍまでの範囲であると希土類磁石自体に欠けや割

れなどの損傷を与えずに良好な皮膜を形成可能である。この粒子は空気または高圧不活性ガスまたは空気と高圧不活性ガスの混合物を用いて吹き付けることが工業上望ましい。この時の粒子を吹き付けるときの速度は５０～２０００ｍ／ｓの範囲である。さらには、所定の組成を有する第１の粒子を希土類磁石の表面に衝突させて希土類磁石表面の清浄化および下地膜を希土類磁石表面に形成し、その後前記第１の粒子とは異なる組成を有する第２の粒子を希土類磁石の表面に衝突させ、２種類以上の組成が積層された多層膜を形成することができる。多層構造であればこの下地膜の厚さは１０μｍ以下であっても十分な耐蝕性を確保できる。

【０００８】

本発明の希土類磁石とはＲ－Ｔ（－Ｍ）－Ｂ（－Ｃ）系、Ｓｍ－Ｃｏ系、Ｒ－Ｔ（－Ｍ）－Ｎ（－Ｂ）系等を主に指すがそれ以外のものであっても効果は本発明と同様のものが得られるのは当然である。ここでＲとはＹを含む希土類元素のうちの１種または２種以上、Ｔは遷移金属、ＭはＴｉ、Ｖ、Ｃｒ、Ｗ、Ｍｎ、Ｇａ、Ａｌ、Ｓｎ、Ｔａ、Ｎｂ、Ｓｉの１種以上を指すものである。

【０００９】

【発明の実施の形態】

（実施例１）

本発明の実施したときの詳細を次に述べる。まず固定ガン方式のショットブラスト機を用い、ノズルの先端から元圧０．２～１．０ＭＰａの空気を高速で噴出させた。そのとき、粒子径１０～６００μの、Al_2O_3，Ｚｒ，Ｎｉ，Ｃｕ，Ｓｎ、Ｚｎ，Ｃｒの各単体金属粒子を個別にこの空気流にのせて、１００～２００ｍ／秒で被処理物である永久磁石に吹き付けた。もちろん、吹き付けられる粒子の速度は高速であるほど、粒子の運動エネルギーは高まり、皮膜の形成は容易となる。しかし、あまりに粒子の速度が速いと、粒子の衝突時に磁石表面の温度が高温になりすぎ、磁石表面の組織を変質させてしまう可能性がある。従って、最適な粒子の速度は、５０ｍ／秒～２０００ｍ／秒の範囲にあることが望ましい。この粒子速度の範囲では、磁石表面の温度上昇は５００～９００℃の範囲に抑えられるため、磁石表面は１～１０μｍの範囲の深さで高温になるが、それより深層部では温度上昇は進まないため、磁石の磁気特性を低下させるようことは無い。ここで用いた永久磁石はＮｄＦｅＢ系をベースとし、それに磁気特性を確保するために微量の添加元素（Ｃｏ，Ｄｙ，Ｔｂ，Ａｌ，Ｎｂ，Ｃｕ，Ｃｒ，Ｅｕ）を必要に応じて加えたことによる試料を用いた。磁石の形状として、１５ｘ４５ｘ３ｍｍのブロック磁石、外径３０ｘ内径１０ｘ厚２ｍｍの薄肉形リング磁石、３０ｘ５０ｘ１０ｍｍの大型ブロック磁石、３５ｘ４０ｘ８ｍｍ、内Ｒ１５０ｍｍ、外Ｒ１５８ｍｍのアークセグメント磁石を用いた。

【００１０】

吹き付け角度は、試料の面に噴射流が垂直にあたるようにし、ノズル先端から試料表面までの距離は１００～２００ｍｍであった。ショットに使用したノズルの直径は２ｍｍえあり、材質は超鋼材を用いた。ショットに要した時間は各面につき２０秒であった。この条件のもとで、磁石上に形成された皮膜の膜厚を次の表１に示す。

【００１１】

【表１】

磁石表面の皮膜膜厚（μｍ）

粒子材質	Al203	Zr	Ni	Cu	Sn	Zn	Cr
膜厚	1	3	8	13	22	27	10

【００１２】

表１の結果が示す様に、磁石表面にはＣｕ，Ｓｎ，Ｚｎ、Ｃｒでは実用的に十分な厚さの膜が形成されたが、他の元素では膜厚が薄く形成された。磁石表面に形成された皮膜の膜厚の分布は、今回実施した３種類の磁石の形状の違いによる影響はなかった。形成された

皮膜の下地磁石との密着強度は、引張試験によると１００～２５０ｋｇ／ｃｍ^{2}の範囲にあり、皮膜の密着強度としては実用的に十分な範囲であった。

【００１３】

（実施例２）

各磁石の表面をAl_2O_3にてあらかじめショットブラストをかけ、表面状態を一様にした後、Al_2O_3以外の金属を噴射し皮膜の形成を確認した。これは、Al_2O_3粒子を磁石に吹き付けた場合、皮膜はわずかの厚みにしか形成されず、むしろブラスト効果により、磁石表面が研磨され、Al_2O_3の吹き付け前に比べて均一な表面状態が得られることを確認できたためである。このような現象は、Al_2O_3のほかに、Ｚｒ，Ｃｒ、Ｎｉでもみられるため、これらの材質をあらかじめ永久磁石表面に吹き付けることにより、表面清浄の効果を得ることができる。また、これらの材質では非常に薄い膜が磁石表面に形成されることから、異種材質による多層膜の形成を行うことも可能である。本実施例の場合、Al_2O_3の噴射時間は、各磁石とも２０秒であり、その他の金属の噴射時間もそれぞれ２０秒である。この結果、得られた皮膜の材質別膜厚を表２に示す。

【００１４】

【表２】

磁石表面の皮膜膜厚（μｍ）

粒子材質	Ｚｒ	Ｎｉ	Ｃｕ	Ｚｎ	Ｃｒ
膜厚	5	11	14	24	9

【００１５】

表２の結果が示す様に、Al_2O_3粒子をあらかじめ磁石表面に照射しても、その後につける金属膜の膜厚には大きな差は見られなかった。しかし、Al_2O_3の事前照射により、磁石表面の付着物がとれ、凹凸の変化も小さくなったため、金属膜をつけた際の膜厚のばらつきは、Al_2O_3を照射しない場合に比較し、８μｍ→３μｍと低下した。形成された皮膜の膜厚分布は、実施例１の場合と同様に、磁石の形状による差異はなかった。皮膜の密着強度は１００～２００ｋｇ／ｃｍ^{2}の範囲にあり、実施例１の場合にくらべ改善されたことを確認した。

【００１６】

（実施例３）

固定ガン方式のショットブラスト機を用い、ノズルの先端から元圧０．２～１．０ＭＰａの空気を高速で噴出させた。第一の粒子として粒子径１０～６００μｍのＮｉ合金を用いた。この金属粒子を前記ショットブラス機により１００～２００ｍ／ｓで被処理物である永久磁石に吹き付け、膜圧８μｍのＮｉ膜を得た。その後、第二の粒子として粒子径１０～６００μｍのＣｕ合金を用いた。第一の粒子と同様に希土類磁石の表面に吹き付けることで膜圧１２μｍの膜圧を形成した。これにより希土類磁石の表面にＮｉ－Ｃｕからなる多層膜を形成した。

【００１７】

【発明の効果】

本発明は、上記の説明の内容からわかるとおり、ショットブラスト機のような低価格で簡便な構造の設備を用いるのみで、磁石表面に皮膜を形成させることができ、膜形成工程を短時間で完了させることができるため、従来の皮膜形成方法に比較して、大変に低コストで磁石表面に保護膜を形成させることができる。